

Contemporary Trends in Engineering Entrepreneurship Education*

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This study investigated the contemporary dimensions of engineering entrepreneurship education aiming at creating a landscape of the most important theories and trends found in the literature, mapping the most important authors, countries, and journals and the often-used research methods. The research methodology included a systematic literature review, combining bibliometrics, networks, and contents analysis. The sampling process was conducted in the Web of Science and Scopus databases, with two filters: research areas (engineering field) and document types (articles and reviews). The sample of 324 articles published from 2001 to 2017 was analyzed in-depth. The results show an exponential growth of interest in the study of engineering entrepreneurship education, with 74% of the samples published in the last 3 years. There is a trend of transition towards a more confirmatory research perspective. There is an increasing focus of the literature on the development of educational programs and methodologies and, consequently, on the evaluation of the results. Two dimensions of contemporary engineering entrepreneurship education stood out: the influence of entrepreneurship education on students' entrepreneurial intention and the definitions of entrepreneurship education. Finally, three main clusters of the literature were identified: entrepreneurial behavior and entrepreneurial intention; entrepreneurship education; and entrepreneurship education challenges, results, and best practices.

Keywords: entrepreneurship; entrepreneurship education; engineering education; systematic literature review; bibliometrics

1. Introduction

Create successful innovations is currently one of the most important and challenging tasks for established companies [1]. There is a strong relationship between innovation and entrepreneurship [2], and the emergence of the hypothesis-driven entrepreneurship paradigm [3], based on the effectuation principles proposed by Saravasthy [4], revolutionized traditional entrepreneurship methodologies because of its fast prototyping [5] and iterative learning [6]. As a consequence, entrepreneurship research is consistently growing [7, 8], resulting in renewed bodies of knowledge that are spreading fast and being widely recognized and applied [9, 10].

At the macro-level, economists and politicians argue that a higher level of entrepreneurship is positively associated with a higher success rate of innovations, economic growth, and technological progress [11–13]. Entrepreneurs act as job creators and economic growth catalysts and can benefit from incentive policies [14]. These stimulate the growth of related bodies of knowledge concerned with creating and developing effective entrepreneurship initiatives [15]. A research with politicians from the United States of America and Europe evidenced that promoting economic growth based on the exploration of innovations requires entrepreneurship [16]. Additionally, providing an educational curriculum that emphasizes entrepreneurial activities improves the quality of the resulting entrepre-

neurs, who will generate radical innovations and business value, connecting business and learning [17].

Universities perform a relevant role in the promotion of entrepreneurial thinking and acting, resulting in initiatives that can contribute to social and economic development, impacting the growth of regions and cities [18]. Entrepreneurship education influences entrepreneur success and promotes self-employment [19, 20]. As a consequence, the impact of education on entrepreneurial business success is historically a relevant research theme [19]. Academic institutions have been increasingly interested in entrepreneurship education [9, 21–23], especially because of the entrepreneurs' capability to generate relevant innovations for markets, economies, and countries [17, 24], creating an academic relevant area [13] that includes a growing number of educational programs, inside and outside the engineering field [22]. Entrepreneurship education is positively associated with entrepreneurial behavior [25] and more effective educational programs impact economic development [26] and benefit economic activity [17]. There is a need for a better understanding of the outcomes of entrepreneurship education [21, 27], aiming to analyze entrepreneurship as an effective diffuser of entrepreneurial intention and a developer of desirable entrepreneurial knowledge and skills [28].

Research concerning entrepreneurship education is growing rapidly throughout the world, evidencing

relevant results and supporting public and private investments [27]. The core idea is that entrepreneurship education can promote the development of adequate skills and competences for a student to become a successful entrepreneur, contradicting the idea that entrepreneurial skills and competences are innate personality traits [12, 16]. Entrepreneurship education stimulates a student's intention to start a new business [12, 28] and results in opportunities for educators to influence aspirations of entrepreneurship [29]. The concept of entrepreneurial intention is receiving growing attention, particularly in understanding its development and in identifying entrepreneurial behavior, besides understanding about the development of intentions [21]. Entrepreneurship educational methods combine learning theoretical concepts and experimenting, with a portfolio of techniques to create assumptions and practices that will assist thoughts and actions in the search for success [9, 29].

However, despite the new possibilities that emerged with the adoption of the hypothesis-driven entrepreneurship approach, with the application of design methods for research and creation, and with the use of fast prototyping techniques to create and to validate products and services with potential customers, there is no research aiming to clarify the most important concepts, approaches, methods, and techniques of the contemporary entrepreneurship education. Therefore, this research aims to contribute to the knowledge regarding contemporary entrepreneurship education, and the following research questions are proposed (RQs):

RQ1: What are the dimensions of the contemporary entrepreneurship education?

RQ2: Considering the identified scenario, what are the most important research methods, authors, countries, and relevant journals concerning engineering entrepreneurship education?

Aiming to answer the proposed questions, a systematic literature review was conducted [30], combining bibliometrics, networks and contents analysis, including papers concerning education and entrepreneurship, published at the ISI—Web of Science and the Scopus databases. The research approach was chosen because of its capability for synthesizing high quality materials [31], evidencing relevant material from a research area [32]. The results evidence the most relevant themes considered in entrepreneurship education research, the most important conceptual research approaches applied by academics and practitioners, and evidence current and future research opportunities concerning entrepreneurship education, contribut-

ing to the research agenda of entrepreneurship research centers.

This article is structured into six sections. Section 1 presents the context of the research, entrepreneurship education. Section 2 presents the research design, a systematic literature review including bibliometrics, networks, and contents analysis. Section 3 provides the results from applying the quantitative methods, bibliometrics and networks. Section 4 gives the results of the qualitative method, contents analysis. Section 5 discusses the results and possible future research directions. Section 6 concludes the study and highlights its contributions.

2. Research methods

A systematic literature review was performed to analyze the current literature on entrepreneurship education, and to evidence the connections between entrepreneurship and engineering education. This systematic literature review explored the evolution of knowledge regarding the subjects using bibliometrics, networks, and contents analysis, which are complementary methods [31]. The papers regarding entrepreneurship and education were extracted from ISI—Web of Science database and Scopus database.

A systematic literature review supports the identification and the synthesis of evidences from relevant studies of a research field [32]. It allows constructing a database for future research, developing a roadmap that investigates causes, effects, processes, and structures, promoting the identification of research gaps and, as a consequence, future research opportunities [33, 34]. By structuring the current literature of a particular research area, limitations are evidenced, as well as relevant research themes that are developing fast [35]. Fig. 1 illustrates the systematic literature review workflow performed in this study.

2.1 Sample and procedures

An initial search in ISI—Web of Science (WoS) and Scopus databases was performed to obtain the sample. The first database, ISI—Web of Science (WoS), was selected to identify papers from indexed journals with the relevant impact factor (JCR—Journal Citation Report) from different databases. The Scopus database was chosen due to its access to the world's largest number of abstracts and citations of peer-reviewed research literature. Working with both databases allowed the development of bibliometrics, networks, and contents analysis, including the summary, references, year of publication, number of citations, country, institution, authors' name and impact factor.

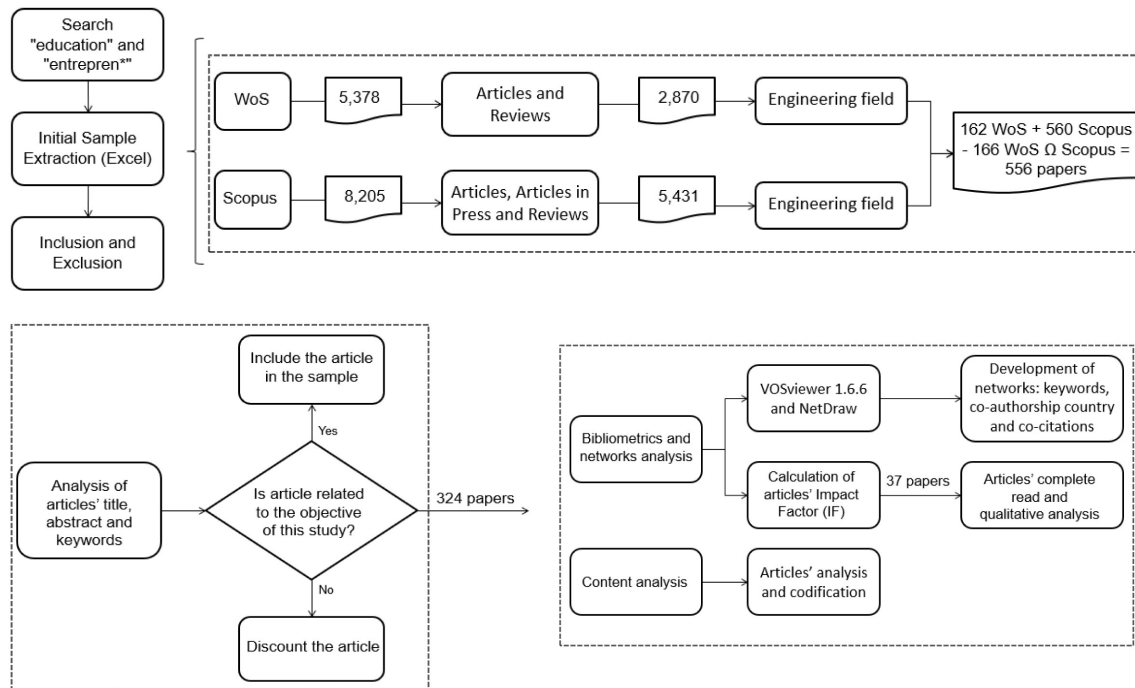


Fig. 1. Systematic literature review workflow.

The research strings were “education” and “entrepren*”. The initial WoS search resulted in 5,378 papers at the end of 2017. The application of a “document type” filter, selecting only articles and reviews, reduced the search results to 2,870 papers. The application of a last filter selecting only papers related to engineering, obtained a sample with 162 papers. With the Scopus database, the application of the same search strings and time period resulted in 8,205 papers. The application of a filter selecting only articles, articles in press, and reviews, resulted in 5,431 papers. Applying the subject engineering field filter resulted in 560 papers. The engineering field was selected because it is the field of interest for this study researches, and also because engineering courses have generated a growing number of graduate students that create successful new firms after graduation [36].

The total number of papers from both databases was 722. From this, 166 papers were excluded as duplicates, being on both the WoS and Scopus databases. The number of papers for analysis, therefore, amounted to 556 papers. Titles, keywords, and abstracts were analyzed qualitatively to search for themes that concerned entrepreneurship education. Research themes which were not in alignment with the scope of this research included: entrepreneurship education as demographical data, the role of family in entrepreneurial life, entrepreneurial behavioral and the effect of gender, and the acceleration of startups in programs inside universities. These papers were withdrawn from the sample, because

the focus of this research was better understanding the concept of entrepreneurship education and themes related to the subject. From this, 324 relevant papers were found.

2.2 Bibliometrics and networks analysis

In bibliometrics analysis, the analyzed authors are assumed to have cited the most important documents from a specific research field, representing a collection of articles and resulting in a citation and co-citation analysis [37]. Bibliometrics analysis enables the global exploration of a research field from empirical evidence [38]. This results in a summary of the most important research topics and trends [39–41], providing a guide for current and for potential future studies [39]. In a bibliometrics analysis, data obtained from papers are studied [42] to show the development and growth of a research topic [43]. This is useful for systematically assessing interdisciplinary research initiatives [44] and for emphasizing the scenario of science publications through the statistical analysis of publications [45]. Networks analysis allows a better understanding of pattern publication in the researched databases [46]. Applying both techniques results in an indispensable guide, drawing technological and scientific roadmaps of a research field, in order to investigate the activities of publications [47].

The description of the sample, research procedures, and bibliometrics and networks analysis steps were as follows. First, the number of publica-

tions per journal and per year were analyzed, evidencing the journals that were interested in the theme and the evolution of the number of publications over the years. Next, all the papers and references were analyzed to create three citation networks: keywords, co-authorship countries, and co-citations. The networks analysis used the VOSviewer 1.6.6 software for constructing and visualizing networks and the NetDraw software for visualizing and editing the social network data.

The bibliometrics and networks analysis evaluated the body of the literature, characterizing the literature by journals, institutions, countries, publication type, subject categories, citations, and content analysis using keywords [48]. The results from this initiative included the analysis of publications by countries, the quantity of papers, the most active authors per journal, the most relevant subjects by journal, paper citations, subject categories, year of publication, journal country of origin, journal impact factor, relevant citations, and important collaborations [40, 47]. Research initiatives also applied qualitative and quantitative techniques and included mathematical and statistical methods to evidence quantitative relationships, distributed architectures, quantitative management, and various patterns of documents. This made it possible to investigate the structures, patterns and characteristics of the underlying sciences [43].

The calculation of the impact index of the identified papers was applied to evidence the most cited articles, following the guidelines proposed by Carvalho et al. [31] resulting in the Impact Factor (IF) for this study. For this, the research applied Equation 1, where (C) represents the number of the paper's citations, (CY) represents the current year and (PY) represents the paper year of publication, evidencing the paper citations pondered for years, with the (JCR) representing the impact factor of the journal in which the paper was published, based on its Journal Citation Report, in 2017. This equation was selected for its capability for comparing papers published in different journals, with different numbers of citations and years of publication, because the authors of this research believe it is necessary to consider all these criteria to prioritize the selected papers of interest. After the IF calculation, the papers were organized in decreasing order of relevance, considering the IF. Inspired of the study by Takey and Carvalho [46], a Pareto analysis was performed to select the papers representing at least 80% of the identified IF, resulting in 37 papers, as the 80% most cited papers. These papers were considered in the qualitative contents analysis, and the results are presented in Section 4.

Equation 1 – Calculus of Impact Factor (IF)

$$IF = \left(\frac{C}{\left(\frac{CY}{CY-PY} \right)} \right) \times (JCR + 1)$$

Source: Carvalho et al. (2013)

2.3 Contents analysis

The contents analysis performs an important role in identifying research approaches and can be applied to different research domains [49], helping with data collection and analysis [50, 51]. It can be used to conceptualize research questions in different new ways [49], to compare and to contrast the findings from a literature review [52], and to evidence common practices, constraints, or interpretations of the observed relationships [49], considering the account of frequency in a longitudinal assessment systematically collected and analyzed [53].

The contents analysis of this research is divided into two categories: quantitative and qualitative. The results of the quantitative analysis are presented in Section 3, and develop a coding scheme for the 324 papers. The qualitative research results are presented in Section 4, which is an in-depth investigation of 37 papers considered outliers, based on the most cited papers and the impact factor of the journals in which they were published.

3. Quantitative results

This section presents the results of the quantitative analysis performed in this research, in the form of a bibliometrics and networks analysis.

3.1 Bibliometrics and networks analysis

An initial overview based on descriptive statistics presents the number of publications year evolution regarding entrepreneurship education, in the engineering field. 74% of the sample were published in the last three years (2014–2017) and the most relevant year is 2017, evidencing a fast increase of interest in the subject, see Fig. 2.

Considering the article sources, 135 different journals published papers concerning entrepreneurship education; however, about one-third of the publications (32%) occurred only in six journals: *Education and Training*; *Journal of Technology Transfer*; *International Entrepreneurship and Management Journal*; *International Journal of Engineering Education*; *Advanced Science Letters*, and *Journal of Small Business Management*.

The keywords network (see Fig. 3) shows the most mentioned keywords obtained from the final paper sample, connected by lines. The strength of the lines indicates the intensity of the identified

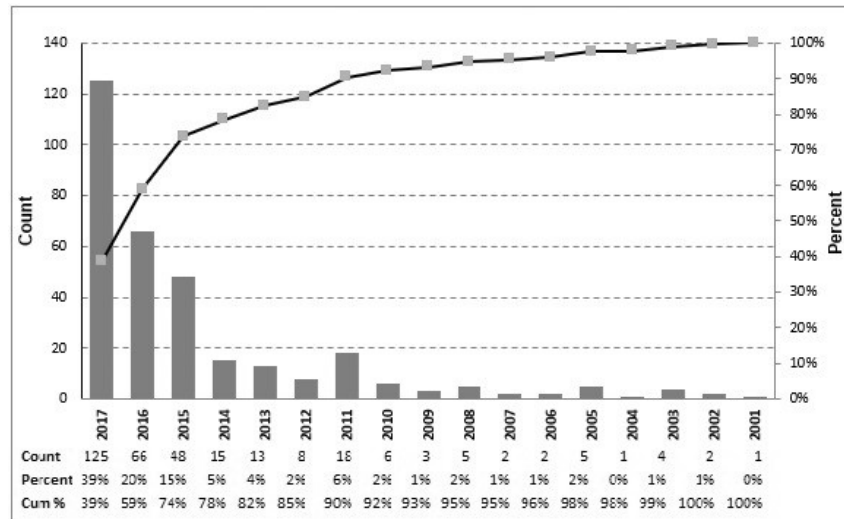


Fig. 2. Yearly evolution of publications on engineering entrepreneurship education (2001–2017).

Table 1. Evolution of the main journals publications per year

Journal	Year											Total			
	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007		2006	2005	
EDUCATION AND TRAINING	17	7	11												35
JOURNAL OF TECHNOLOGY TRANSFER	14	4	2												20
INTERNATIONAL ENTREPRENEURSHIP AND MANAGEMENT JOURNAL	2	2	2	1	1		6								14
INTERNATIONAL JOURNAL OF ENGINEERING EDUCATION	2	3	1	1	1	2		1					1		12
ADVANCED SCIENCE LETTERS	8	1	2												11
JOURNAL OF SMALL BUSINESS MANAGEMENT			2	3		5	1								11
Total	43	19	21	2	7	2	7	1	0	0	0	0	0	1	103

relationships. After performing the network analysis, it was concluded that, to provide better visualization, the filter should have a minimum of six citations per keyword, leading to a final network with thirty-nine main keywords. Then, a Pareto analysis was conducted to narrow the keywords analysis, summarizing only the 80% most representative, namely: entrepreneurship education, education, entrepreneurship, entrepreneurial intention, students, business, behavior, universities, innovation, self-efficacy, creation, performance, model, opportunities, impact, higher-education, perspective, knowledge, scientists, and technology.

The analysis of Fig. 3 evidenced three clusters of keywords. The first cluster is related to the development of students' competences and behaviors (model, impact, business, behavior, creation, entrepreneurial intention, students and self-efficacy). The second cluster evidences the effective assumption of entrepreneurship education (entrepreneurship education, entrepreneurship, perspective, education and opportunities). Finally, the last cluster represents the key variables related to entrepreneurship education, including: the most important universities in this business field, the most important places

where entrepreneurship education happens, the sources of technology applied to the educational process, types of innovation, relevant scientists, performance measures, and created knowledge. Specifically analyzing the most relevant connections, it is possible to highlight the connections between entrepreneurship education and entrepreneurial intention, entrepreneurial intention and students, entrepreneurial intention and behavior, entrepreneurship education and creation, creation and students, and entrepreneurship and education.

The sample included in the network co-authorship analysis showed research conducted in sixty different countries. To highlight the most relevant ones, only countries with more than four articles were considered, resulting in a network with twenty-three countries, presented in Fig. 4. In this figure, it is possible to visualize the three main clusters. One cluster evidencing the United States of America and England as key nodes, connected to many different countries (Australia, Belgium, Brazil, Denmark, France, Germany, Iran, Italy, Malaysia, Mexico, Netherlands, Norway, South Africa, Spain, Sweden, and Wales); it is possible to observe that this is the main cluster in entrepreneurship educa-

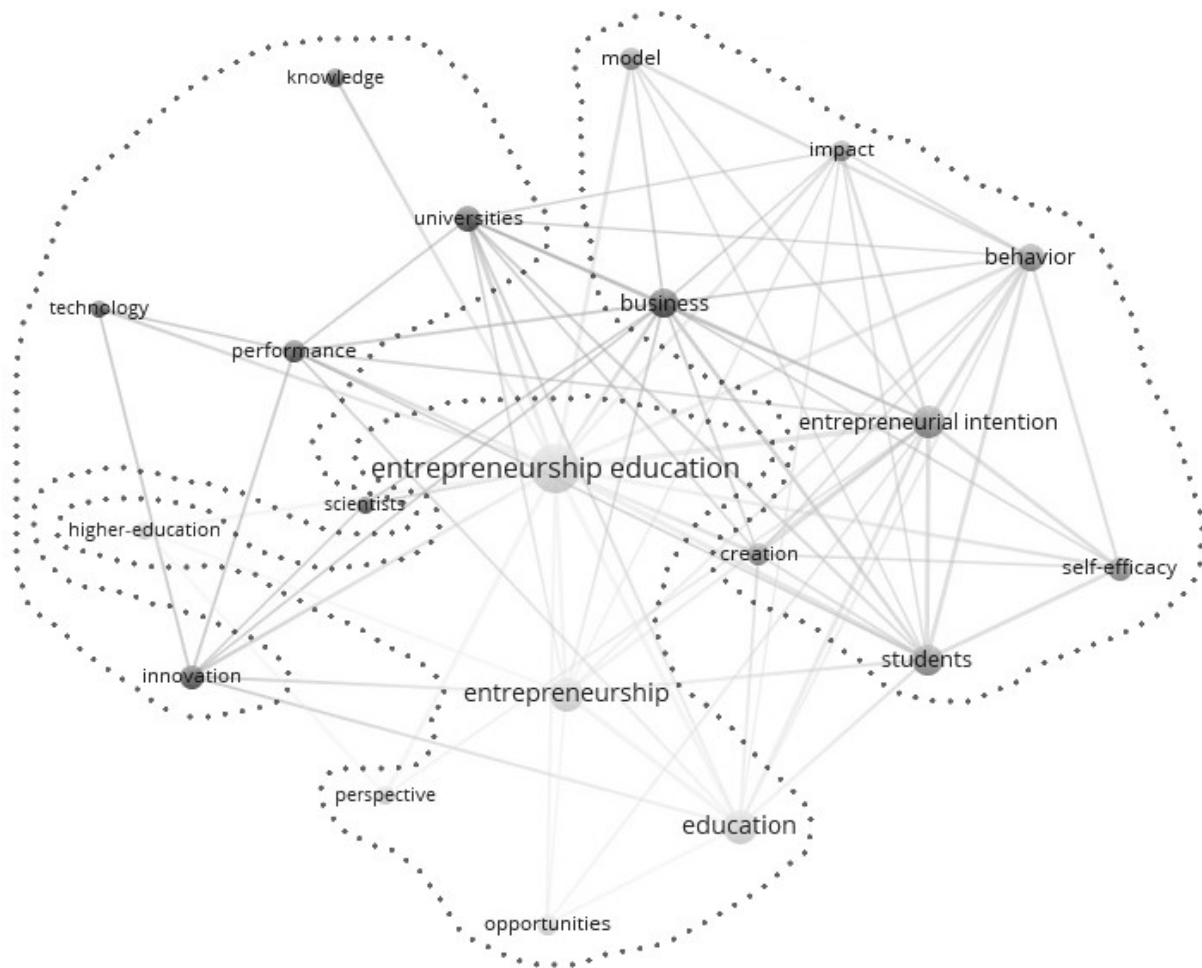


Fig. 3. Keywords network of entrepreneurship education.

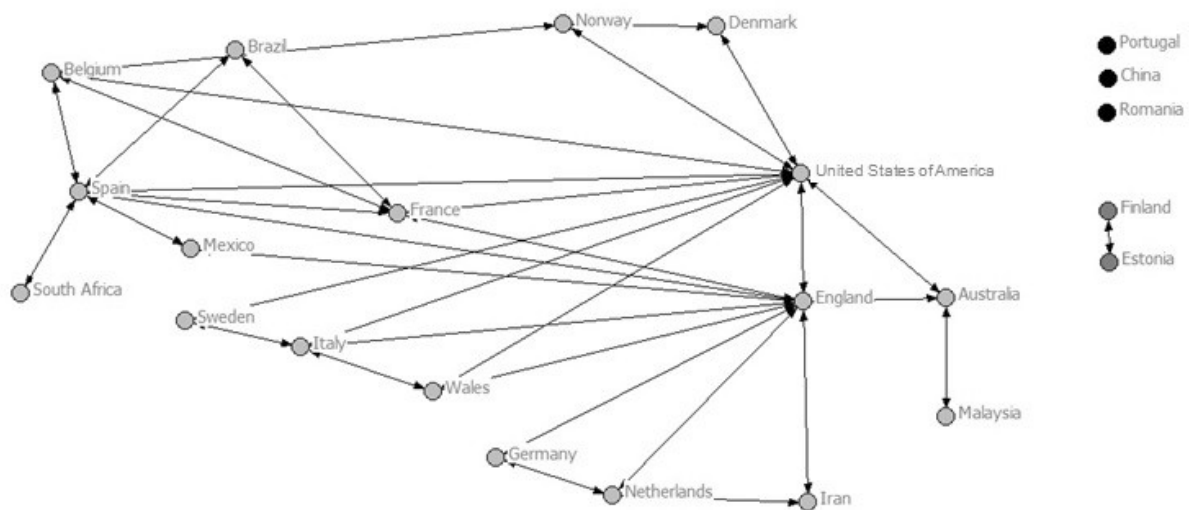


Fig. 4. Co-authorship country of entrepreneurship education.

tion. The most important connections identified occurred between the United States of America and England, England and Wales, England and Germany, and the United States of America and

France. Another cluster is composed of Finland and Estonia, two countries geographically close presenting entrepreneurship educational initiatives jointly conducted. Finally, the last cluster includes “iso-

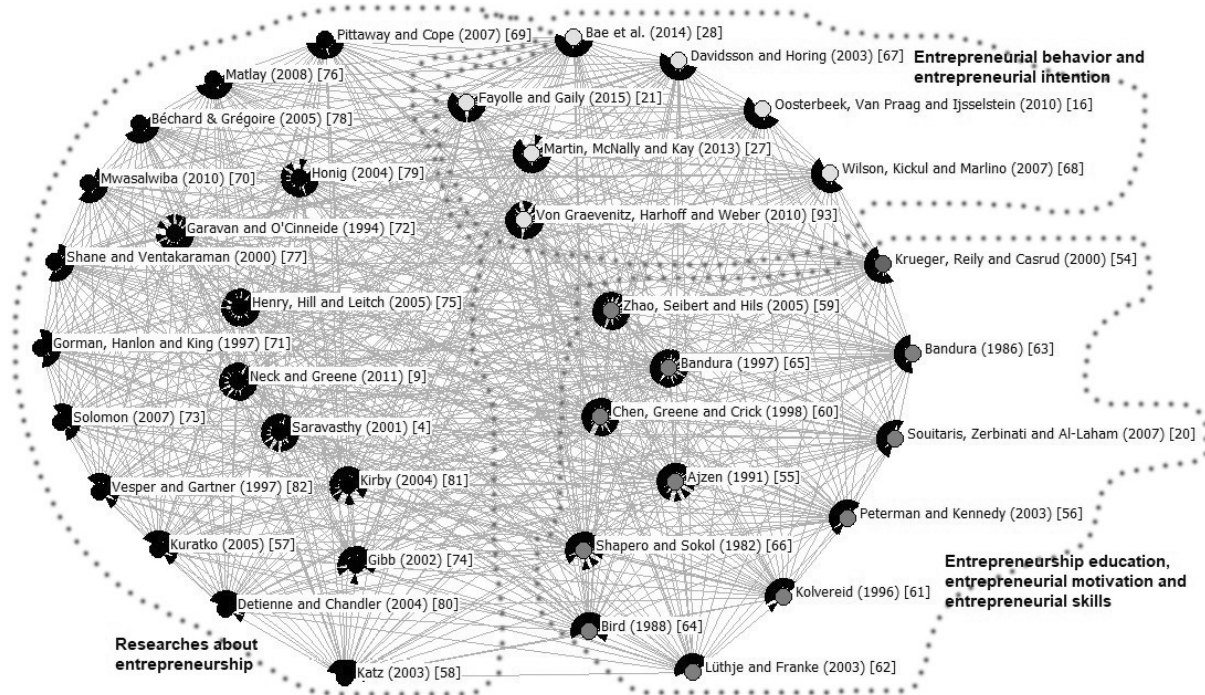


Fig. 5. Most co-citations references on entrepreneurship education.

lated countries”, i.e., countries whose research presents no connection with other countries (China, Portugal, and Romania).

The sample cited 10,674 references and, aiming to obtain a network with better visualization, this research only considered authors that had at least twenty citations and citing references. The results are presented in Fig. 5 and include thirty-seven papers, grouped into three main clusters. The first cluster consists of twelve papers that present outcomes from researches about entrepreneurial behavior and entrepreneurial intention. The second cluster includes seven papers concerning research about entrepreneurship education relates to other subjects of interest, such as entrepreneurial motivation and entrepreneurial skills. The last cluster is composed of eighteen papers concerning research on entrepreneurship education review, challenges, outcomes, and best practices to conduct entrepreneurship education initiatives. The most important connections identified occurred between Krueger et al. [54] and Ajzen [55], Ajzen [55] and Souitaris et al. [20], Souitaris et al. [20] and Peterman and Kennedy [56], Peterman and Kennedy [56] and Kuratko [57], and Kuratko [57] and Katz [58]. These connections evidence relationships between authors researching entrepreneurship education regarding other subjects of interest, such as entrepreneurial motivation and entrepreneurial skills, and entrepreneurship education reviews, challenges and outcomes, and how entrepreneurship education is taught.

Analyzing the co-citation network references (Fig. 5), it is possible to visualize three clusters. There is a cluster with a focus on students' intentions to become entrepreneurs [59]; researches related to the effects of entrepreneurial programs on entrepreneurial attitudes and entrepreneurial intentions [20], and the desirability and feasibility of starting a business [56]; the prediction of entrepreneurial intentions [54, 55, 60–62]; and the entrepreneurial motivation and entrepreneurial action [63–66]. A second cluster evidences entrepreneurship education and entrepreneurial intention [11, 28]; entrepreneurship education and entrepreneurial motivation and entrepreneurial skills [16]; entrepreneurship education developing more and better entrepreneurs [27]; reasons for the increase of the number of entrepreneurs [64, 65]; and evaluations of entrepreneurship programs [21]. Finally, the last cluster includes papers concerning systematic literature reviews on entrepreneurship education [66–70]; teaching entrepreneurship [9, 71–76]; entrepreneurship education, outcomes and important contents [55, 73, 77]; entrepreneurship education and challenges [54, 78]; the rank of entrepreneurship programs [79]; different kinds of entrepreneurship [4].

Looking at the contents analysis and the keywords network analysis, it is possible to observe convergences. The three clusters identified in the keywords network (Fig. 3) highlight entrepreneurship education, entrepreneurship intention and per-

Conceptual research approaches	Empirical research approaches
CR1 - Literature review	ER1 - Survey
CR2 - Simulation theoretical-conceptual	ER2 - Case study
CR3 - Website or documental analysis	ER3 - Action research
Research objectives	Key variables
LA1 - Evaluation of methodology or education program	KV01 - Entrepreneurial behavior or competences
LA2 - Evaluation of institution, geographic region or country	KV02 - Design in academic entrepreneurship
LA3 - Scenario of institution, geographic region or country	KV03 - Social responsibility in academic entrepreneurship
LA4 - Development of methodology or educational program	KV04 - Innovation and entrepreneurship
LA5 - Comparison between methodology or educational program	KV05 - Cultural influence in entrepreneurship
LA6 - Comparison between institution, geographic region or country	KV06 - Influence of entrepreneurship education on students' career choice
	KV07 - Influence of entrepreneurship education on students' entrepreneurial intention
	KV08 - Technology and entrepreneurship
	KV09 - Commercialization and promotion of entrepreneurship
	KV10 - Definition of entrepreneurship education
	KV11 - Knowledge and entrepreneurship
	KV12 - Employability and entrepreneurship
	KV13 - Entrepreneurship influencing universities
	KV14 - Sustainability and entrepreneurship

Fig. 6. Coding schema applied to the content analysis.

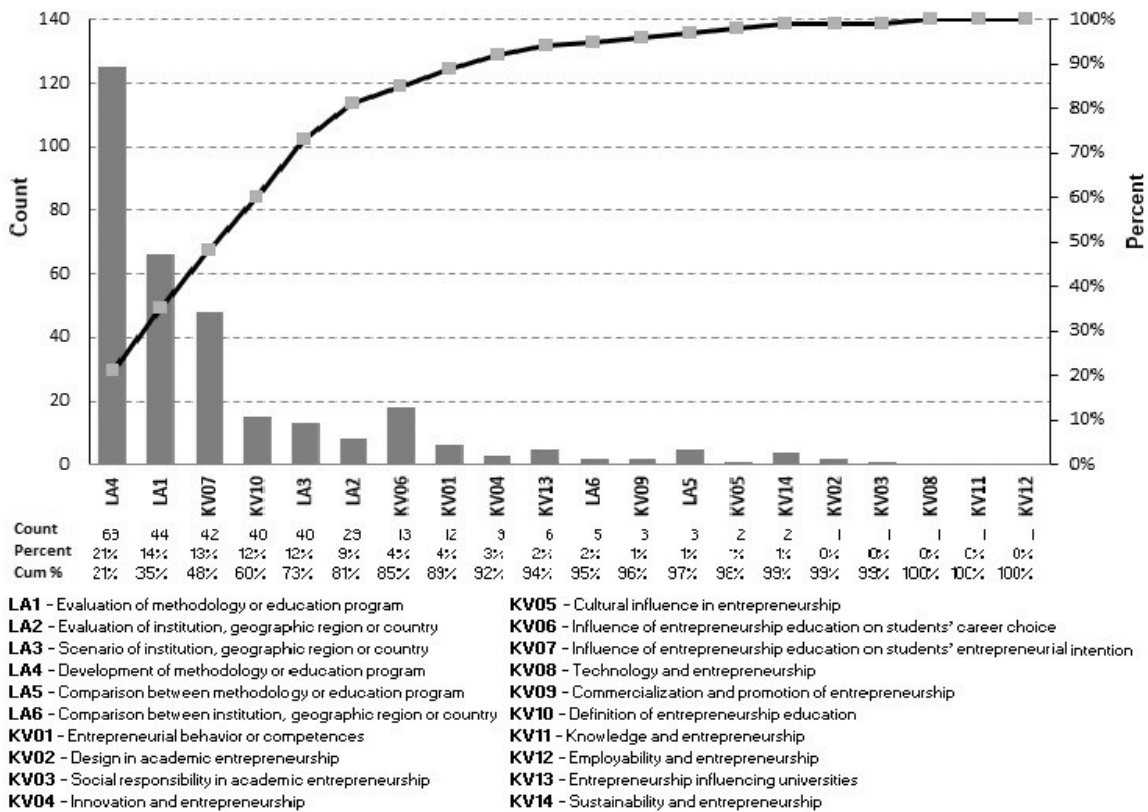


Fig. 7. Codes frequency of content analysis.

formance. The keyword network evidences different units of analysis, particularly universities and students. Considering the most frequent keywords, the most relevant interests are entrepreneur behavior (9% of the sample) and entrepreneurial intention (31% of the sample). In the co-authorship country network (Fig. 4), it is possible to visualize three clusters, among them the cluster formed by the United States of America (34%) and England (21%).

3.2 Content analysis

All the papers from the initial sample (324 papers) were analyzed considering their titles, abstracts, and keywords, resulting in a publications coding schema that classified these papers and resulted in a first scenario, regarding the dimensions of the contemporary entrepreneurship education, which helps to answer RQ1: What are the dimensions of contemporary entrepreneurship education? (see Fig. 6).

Fig. 6 and Table 2 presents the codes and frequency of the researches, evidencing that the most popular approach is literature review (CR1) and the most popular empirical field research approach is survey (ER1). Considering the research objectives, most of the articles identified focused on the development of an educational methodology or educa-

tional program (LA4) and, as a consequence, on an evaluation of the educational methodology and educational program (LA1). An analysis of the key variables showed the influence of entrepreneurship education on students' entrepreneurship intention (KV07) and the definition of entrepreneurship education (KV10).

Table 2 shows the cross-tabulation of the classified articles based on research methods and on research objectives, and key variables, such as the influence of entrepreneurship education on students' entrepreneurship intentions (KV07) and the definition of entrepreneurship education (KV10) with the research method of survey (ER1) and literature review (CR1). Note that the development of methodology or educational program (LA4) is more related to CR1, while the evaluation of methodology or educational program (LA1) is more related to ER1.

For a better understanding of entrepreneurship education and its main related assumptions, the next paragraphs and topics present an exploration of the definition and evolution of these subjects.

The results of the research evidence the growing importance of entrepreneurship education, including an analysis of the growing number of colleges

Table 2. Cross-tabulation of the coding schema applied to the content analysis

	CR1	CR3	ER1	ER2	ER3	Total
LA1	4		25	14	1	44
LA2	1		16	12		29
LA3	7	5	15	13		40
LA4	27	5	18	18	1	69
LA5	1	1	1			3
LA6	1	2	1	1		5
Total	41	13	76	58	2	190

	CR1	CR3	ER1	ER2	ER3	Total
KV01	3		7	2		12
KV02	1					1
KV03	1					1
KV04	6		2	1		9
KV05			1	1		2
KV06	3	2	6	2		13
KV07	5		28	8	1	42
KV08	1					1
KV09		1	1	1		3
KV10	25	1	10	4		40
KV11			1			1
KV12		1				1
KV13	1	2	1	2		6
KV14			2			2
Total	46	7	59	21	1	134

LA1 - Evaluation of methodology or education program	KV05 - Cultural influence in entrepreneurship
LA2 - Evaluation of institution, geographic region or country	KV06 - Influence of entrepreneurship education on students' career choice
LA3 - Scenario of institution, geographic region or country	KV07 - Influence of entrepreneurship education on students' entrepreneurship intention
LA4 - Development of methodology or education program	KV08 - Technology and entrepreneurship
LA5 - Comparison between methodology or education program	KV09 - Commercialization and promotion of entrepreneurship
LA6 - Comparison between institution, geographic region or country	KV10 - Definition of entrepreneurship education
KV01 - Entrepreneurial behavior or competencies	KV11 - Knowledge and entrepreneurship
KV02 - Design in academic entrepreneurship	KV12 - Employability and entrepreneurship
KV03 - Social responsibility in academic entrepreneurship	KV13 - Entrepreneurship influencing universities
KV04 - Innovation and entrepreneurship	KV14 - Sustainability and entrepreneurship

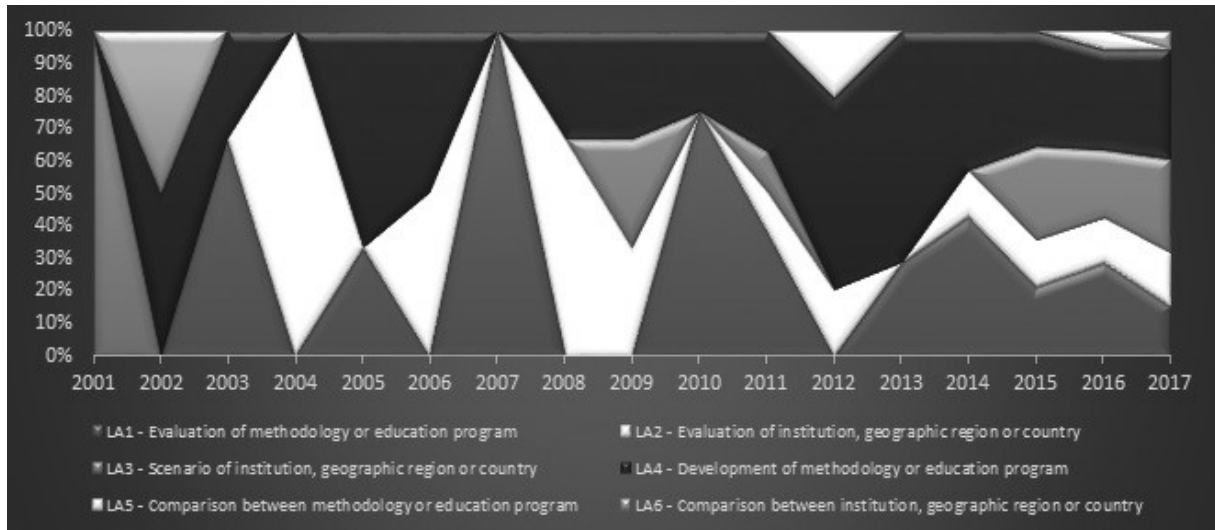


Fig. 8. Evolution of coding schema over time.

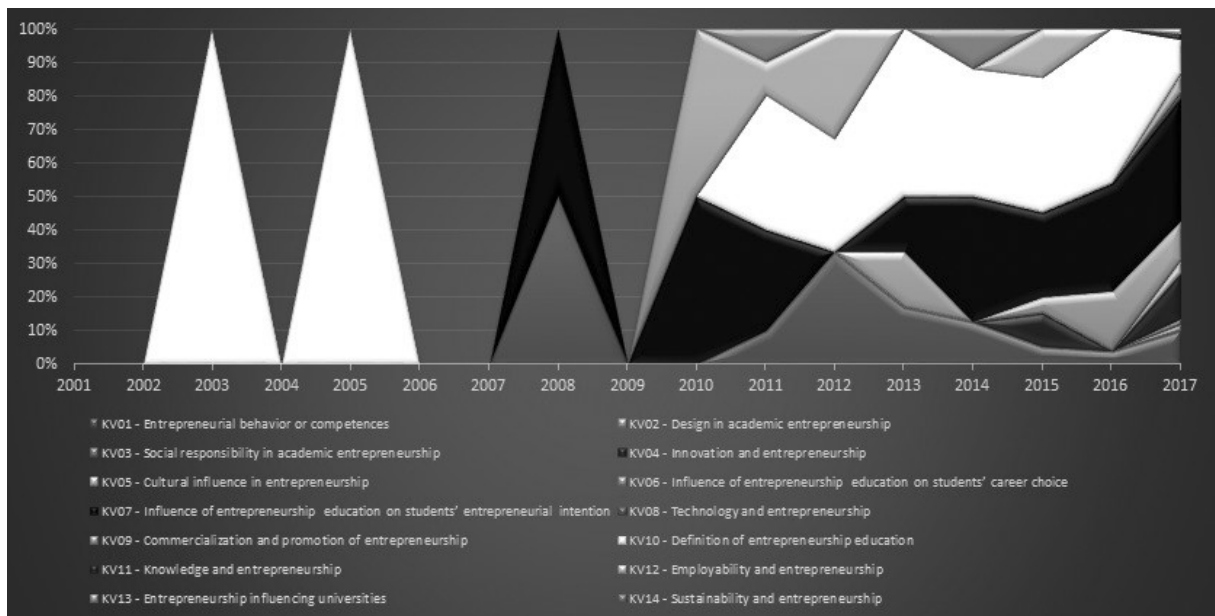


Fig. 9. Evolution of coding schema over time.

and universities that offer courses in the area of entrepreneurship [57, 82] and the growing number of publications since 2015, a period that covers 74% of the papers identified. Concerning the research methods, a significant part of the researches applied empirical field research protocols (67%), most of them survey (42%) and case studies (24%). Just 33% of the papers identified applied conceptual research, particularly literature reviews (27%). Empirical research initiatives can be justified because of the innovativeness of the theme and the need for a better understanding and consolidation of the subjects in this field, as suggested by Vesper and Gartner [83].

Most of the papers investigate the influence of entrepreneurial education on students' entrepre-

neurship intention (42 articles—13%), identify key variables related to the definition of entrepreneurship education (40 articles—12%), and analyze the influence of entrepreneurship education on students' career choice (29 articles—9%). Regarding the proposed research objectives, the most prominent theme identified is the development of methodologies and educational programs (69 articles—21%), followed by the evaluation of the results from the methodologies applied or regarding the educational programs (44 articles—14%), and by the analysis of the impact of the scenarios surrounding the educational initiative, including geographic region and countries (40 articles—12%).

Fig. 8 and Fig. 9 present the evolution of the

relevance of the key variables during the period of analysis. After 2009, different variables are observed to have been explored in several contexts, indicating an improved diversity of scope of research concerning entrepreneurship education. Also note that the focus on developing a methodology or educational program (LA4) and the evaluation of methodology or educational program (LA1) are the most significant key variables during the period of analysis.

4. Qualitative results

This part of the research presents the results of the contents analysis of the 37 outliers' papers. This section emerges from reading and grouping these articles and helps to understand the thinking of the most relevant authors that researched entrepreneurship education until 2017.

4.1 *Entrepreneurs and entrepreneurship*

Successful entrepreneurs can identify and exploit emerging opportunities aiming to solve ecological and societal issues, and whose solutions are integrated into viable, profitable and sustainable business models [84]. Entrepreneurship focuses on identifying market inefficiencies and business processes that are not performing well [14]. It aims to revolutionize market conditions with the introduction of new products and services [80]. The majority of entrepreneurs start businesses in existing markets that are not well served; as a consequence, few new entrepreneurs effectively innovate [14]. Most individuals become entrepreneurs because of inspiration and not because of financial rewards [14].

The entrepreneurship process is chaotic, complex and non-linear [9]. It performs a crucial part in the creation and diffusion of innovations, leading to productivity growth and technological changes, changing the market structure and the competition basis [57]. Entrepreneurship cannot be seen only as the creation of a business, it demands opportunity seeking, risk taking and resilience capabilities that permanently permeate entrepreneurship [57]. Entrepreneurship is important for all kinds of organizations and, in our contemporary society, people must be able to pursue the new and to innovate [10]. Many college and university students go on to create their own business; however, even those without entrepreneurial intentions or skills can greatly benefit from experimentation and acquisition of entrepreneurial knowledge and competences [10].

The first years of the twenty-first century witnessed the emergence of the most entrepreneurial generation since the Industrial Revolution. This new revolution spread throughout the world and

permanently impacted business practices [57]. Currently, there is an agreement that entrepreneurial knowledge and skills can be taught and entrepreneurial competences can be developed [57]. Entrepreneurship education can be an effective diffuser of the entrepreneurial intention, more than a traditional business education, because entrepreneurship education is aimed at developing entrepreneurial knowledge, skills, and competences [28]. As a consequence, the educational market has seen a remarkable growth and development of programs in entrepreneurship and new venture creation, developed and run by established or newly created colleges and universities [57].

Therefore, authors evidenced that entrepreneurship is important for discovering and meeting different market needs, and that entrepreneurship education provides knowledge and develops competences that are useful even for people not pursuing the creation of their own business. As a consequence, it is relevant to explore entrepreneurship education, including entrepreneurial competences that can be taught and promoted by colleges and universities, resulting in a growing number of programs of entrepreneurship education.

4.2 *Entrepreneurial universities and entrepreneurship education*

Entrepreneurial universities create the appropriate environment for the university community to conduct entrepreneurial initiatives, contributing to economic and social development, impacting and influencing the economic growth of cities and regions. These universities contribute to the creation of entrepreneurial actions, thinking and institutions, being more influenced by informal factors, such as role models and attitudes towards entrepreneurship, than by formal factors, such as education, training, and support initiatives [18]. Moreover, generating and transferring knowledge from the university to society provides leadership for entrepreneurial thinking and acting, and for the creation of new institutions [18, 85]. Entrepreneurship education faces new paradigms and it is necessary to revolutionize the university organizational structure as a whole [74].

Discussions about the impact of education on entrepreneurial businesses success is a traditional theme among academics and practitioners [19]. On the one hand, most small business owner-managers have few educational qualifications and do not have the benefits of education themselves. Their focus lies on the business survival, and not in training—themselves or their employees, especially in the first five years [86]. On the other hand, relevant research indicates that education has a positive influence on the success of entrepreneurship [19].

Entrepreneurial education aims to improve managerial skills in small firms, as well as increasing positive characteristics and attitudes of the entrepreneur, which leads to more resilient competitors [86]. There is an explicit correlation between the general level of education and the probability of becoming self-employed and having entrepreneurial success [19].

The first entrepreneurship course was held in 1947, led by Myles Mace in the United States [58]. Since then, the growth of entrepreneurship education has been remarkable, even exceptional [58]. The phenomenon spread over the United States, ten years before it reached Europe [85]. Entrepreneurship education outside North America is currently growing significantly [58].

Entrepreneurship education generally has its origins in business schools [84]. In response to the phenomenon of people returning from World War II and finding an economy in transition, in 1945, Harvard Business School introduced a precursor entrepreneur course [82]. This movement was not significant in the following decades, but during the 1970s, this scenario changed completely. An important factor in the change was the advent of the microcomputer, a tool that exponentially accelerated the capacity of operating complex businesses with reduced production scales and costs [82]. Since the 1990s, books on entrepreneurship have almost doubled in popularity every year and entrepreneurship initiatives have spread into schools of engineering and agriculture [58]. If management education formerly focused mainly on large firms, there currently exists a complementary and also important focus on small businesses [86].

Traditional business and new ventures management education is inadequate for the current societal needs and, with the needs of small business and ventures neglected, there is still little indication of how to meet the needs of this distinguished group [74]. Current research on entrepreneurship must focus on identifying opportunities [80], prioritizing new opportunities based on emerging needs [9]. According to Duval-Couetil [83], the characteristics of entrepreneurship education are singular: (1) as a young discipline, its body of knowledge is still ill-defined; (2) there is no standardization concerning methods and tools; (3) the emphasis is on practice, involving mainly nonacademic practitioners; (4) economic development and business creation are explicitly expected outcomes.

Therefore, in this century, entrepreneurship education is a worldwide phenomenon, with multiple local, national and international competitors. It is considered a discipline that will certainly grow academically in the next years [58]. As a consequence, the area of entrepreneurship education is increas-

ingly academically explored, being considered a new field because the interest started to increase significantly only in the 1990s, resulting in bodies of knowledge that are still ill-defined. It is an interesting area because of the opportunity to promote self-employment and the capability for re-building country markets after great economic problems. Entrepreneurship education is a positive influence of successful entrepreneurs, because of its ability to develop entrepreneurial behavior and competences.

4.3 *Entrepreneurial behavioral and competences*

Entrepreneurship education consists mostly in teaching entrepreneurial skills and attitudes [28]. Entrepreneurship education is effective in stimulating entrepreneurial behavior and increasing students' positive attitudes in achieve to be entrepreneurs [26]. The ability to create sustainable business models in the midst of many adverse situations demands specific skills and competences that are not completely defined yet. This suggests future research possibilities, with a focus on developing effective entrepreneurial programs based on the identification, definition and measurement of entrepreneurial competences [87].

Entrepreneurs' competences combine knowledge, skills, and resources that differentiate one entrepreneur from another [29]. Competences are outcomes from learning from the interactions between individuals and environments, and their improvement is possible based on studies considering pre-measures and post-measures [87]. Competences can be enhanced with good practice and decline without practice [87].

A strategy to develop entrepreneurial competences with the application of existing theories must be tailored and monitored by lecturers and experimented, validated, and approved by students [29]. Instructors can provide appropriate scripts as a foundation for practically developing competences. This process can be measured aiming to discover the most effective teaching approaches [87].

Since the identification of business opportunities is central for entrepreneurship education, it is a competency that must be developed in entrepreneurship classrooms, for improving the number of generated ideas and their innovativeness [80]. Entrepreneurship is a reflective practice; therefore, reflecting on the results from practical initiatives is fundamental and a component of entrepreneurship education [9].

Entrepreneurship has as a fundamental role in the development of sustainable business models, particularly considering the adverse situations that might be faced by the entrepreneurs. In this scenario, some competences, skills, and knowledge, such as the identification of business opportunities,

are recognized to be fundamental for entrepreneurial success, and it can be taught, and even promoted.

4.4 *Entrepreneurial intention*

Although the development of entrepreneurship as a knowledge area is evident, entrepreneurial education still receives significant influence from business courses, raising the question of whether students are receiving the right scripts to become effective entrepreneurs [87]. It is relevant to observe that students develop higher entrepreneurial intention after participating in an entrepreneurial course and perceiving the possible behavioral controls [26].

One of the greatest myths about entrepreneurship is that entrepreneurs are born with specific innate characteristics, and these are difficult, or even impossible, to develop or to learn [84]. Nonetheless, aiming to stimulate entrepreneurial activity, many countries have invested in entrepreneurship education, creating a genuine interest in the outcomes of these efforts, initiating researches that later evidenced positive correlations between entrepreneurship education and entrepreneurial intention [21, 88]. Evidences revealed that different circumstances can modify the level of the entrepreneurship knowledge and affect entrepreneur intention [15], and that entrepreneurship programs result in higher entrepreneurial intention, inspiration and attitudes, leading students towards self-employment [20].

Since acquiring education demands time and money, a greater level of education results in higher opportunity costs and higher expectations about future returns. A study by Block et al. [89] demonstrated that people with higher educational levels are more willing to start a new business, and individuals with fewer years of education are more sensitive to scenarios of uncertainty and less willing to initiate a new venture [8].

However, part of the results from these researches showed contradictory results, which leads to unclear conclusions, demanding deeper examinations of purpose and nature [90]. Oosterbeek et al. [16] concluded that entrepreneurship educational programs do not affect students' skills and negatively affect entrepreneurial intention, because students with low levels of entrepreneurial competencies become even less enthusiastic about starting new ventures. Autio and Acs [8] also verified negative relationships between the individuals' education and entrepreneurial growth aspirations [10]. Fayolle and Gailly [21] highlighted that some recent studies did not find significant impacts after the conclusion of the entrepreneurial programs.

According to Fayolle and Gailly [21], entrepreneurship education affects individuals' intentions and attitudes towards entrepreneurship. However, students become aware of the effect six months after

the participation in an educational program, reinforcing the reflective character of the entrepreneurship education. Therefore, entrepreneurship education presents a positive relationship with entrepreneurial activity, especially at the end of the educational initiative [88]. The relevance of improving educational methods is remarkable, aiming to guarantee for educators the best concepts, techniques, and tools, capable of evolving students perceived behavioral control [25]. This scenario reinforces the relevance of future researches that seek the best educational entrepreneurship programs considering the specific reality of the educational initiative and aiming to stimulate entrepreneurial behavioral [26].

Growing investments in entrepreneurship education have been observed, since entrepreneurship education can positively affect entrepreneurial intention. However, as some researchers concluded that the effect is the opposite (negative), it is clear that the research area still demands more in-depth researches.

4.5 *Entrepreneurial programs categories and evaluation*

Entrepreneurship programs prepare students for an entrepreneurial career. It aims to help students to establish their own businesses [26], and provides competences and knowledge for creating jobs and economic value [83]. However, there is still no agreement about what concepts of entrepreneurship should be explained, no agreement about how new ventures should be initiated, and what complementary tools and techniques should be prioritized, presented, and applied [74].

Different entrepreneurial programs apply different approaches, resulting in different experiences in which students can participate in the "real world", including the development of products and services, business plans competitions, internship programs in startups, and participating in technology transfer activities [83]. Entrepreneurship program approaches can also concentrate on familiar topics, such as creating organizations, developing innovations, startup growth, intellectual property, value creation, and also new topics, such as family businesses, and managing high-growth businesses and smaller enterprises [82]. Educational programs include activities that apply virtual reality and real-world simulations, improving decision-making skills, and even entrepreneurial self-confidence [25].

The specificities of educational programs also impact the perceived entrepreneurial intentions. Programs orientated towards practical aspects achieve different results when compared to theory-oriented programs [90]. Programs can be elective or

compulsory, and, because elective programs are attended by students with higher entrepreneur intentions, they usually obtain better results than compulsory programs [25]. Courses usually take one semester and there are relevant intervals between classes for students to understand and to incorporate concepts, and to develop practical activities [28].

Practical outcomes are currently noticed to significantly differ in courses in which entrepreneurship education focuses on venture creation, with a stronger emphasis on learning-by-doing activities, when compared to courses where focusing on the hypothetical conception of a business and the development of a traditional business plan [28]. In active learning and learning-by-doing contexts, students are not passive and perform activities to promote entrepreneurial action and business creation [91]. It is also important to recognize that, when action principles connect with concrete behavior and with active learning, students receive feedback based on their real-life results. This helps them to understand the action principles and results in mental frameworks as to how to apply them [91]. The action-based entrepreneurship initiatives have positive effects on acquired knowledge, action planning, and entrepreneurial self-efficacy [91].

The evolution of entrepreneurship programs and related business schools demands more debate and dialogue and cannot be considered something solved and fixed [82]. It is of paramount importance for educational institutions to continually measure the outcomes from the programs, including students' satisfaction, performance and the impact on the community [82, 92]. It is also relevant to note that it is inappropriate to evaluate these programs using the same measures traditionally applied to conventional courses [82]. Another relevant issue is related to understanding local, regional, and national conditions to contextualize the outcomes of entrepreneurship education [88]. Research concerning the impact of entrepreneurship education and training can have two focuses: short-term outcomes, including intentions, knowledge, and attitudes; and long-term outcomes, including startup survival [91]. Few studies analyze both short-term and long-term results of entrepreneurship education regarding student attitudes, career goals, behavior, and professional competence [83].

Therefore, there is no consensus about the best entrepreneurial program and this is a subject that still demands in-depth studies, especially because of the many different approaches and tools available. It is even relevant to research different contexts, analyzing economic development and the impact of entrepreneurs before and after their participation in an educational program.

5. Discussion

The results indicate that entrepreneurs are individuals who pursue business opportunities aiming at sustainable business growth and working to fulfill market inefficiencies. The focus lies on creating innovation based on the identification of what is not operating well, resulting in the introduction of new products and services to change market conditions [14, 80, 84]. Entrepreneurs also develop sustainable business models in adverse situations, reinforcing the importance of social responsibility in academic entrepreneurship initiatives. Individuals are inspired to become entrepreneurs and not because their main objective is to make money; however, most entrepreneurs start their businesses in existing markets that are served by established companies and, as a consequence, only few new entrepreneurs effectively innovate [14]. Research results evidenced that the adoption of design approaches to identify innovative business opportunities is a current trend and, therefore, the application of strategic design to identify emerging opportunities characterizes a new multidisciplinary research field, combining concepts and approaches from design, business and engineering.

In countries with a limited number of new jobs in the private sector, entrepreneurship education promotes the creation of jobs for young people and stimulates higher employment and economy growth [23, 26], reinforcing the relevance of researches that characterizes the cultural influence on entrepreneurship. Although entrepreneurship education is especially suited for people that want to run their own business, it can benefit all those who want to develop entrepreneurial competences, behaviours, and knowledge, which are valuable in conditions of uncertainty [10], a trend verified along the development of this research and that can influence students' career choices. The conduction of longitudinal research aiming to verify the relevance of acquiring entrepreneurial competences among non-entrepreneurs is an opportunity to verify the broad relevance of entrepreneurship education.

The entrepreneur process is chaotic, complex and non-linear [9]. It performs a crucial role in the creation of innovations and leads to productivity growth and technological development, changing market structure and competition [57]. Entrepreneurship is not restricted to creating new businesses and is important for all categories of organizations, since all companies must be able to create innovations [10]. Entrepreneurship education can develop competences, knowledge and skills that are very important for entrepreneurial success, and for promoting and encouraging entrepreneurial intention.

The world is currently experiencing the most dynamic period of entrepreneurial activity since the industrial revolution, i.e., a new revolution that spreads across the world and has a definite impact on the business scenario [57]. In this new context, entrepreneurship education can be more effective diffusing entrepreneurial intention than traditional business education, because it is more suitable for developing entrepreneurial knowledge and skills [28]. As a consequence, it a remarkable growth and development of entrepreneurship programs can be verified at universities and colleges [57], in which professionals and business educators consider that entrepreneurs are not “born entrepreneurs” but can be created [57].

To answer the proposed research questions, first, a research was conducted to highlight what the most relevant dimensions of the contemporary engineering entrepreneurship education are, resulting in the following dimensions: the influence of entrepreneurship education on students’ entrepreneurial intention and the definitions of entrepreneurship education. The main academic research objectives identified from the papers analyzed are the development of educational programs and methodologies, besides the evaluation of the results from the application of these methodologies and educational programs, evidencing that entrepreneurship education is a field in consolidation, receiving significant interest from researchers that aim to better understand and to measure the results.

The second research question demanded the identification of the most important research methods, authors, countries, and relevant journals concerning engineering entrepreneurship education. The results revealed the transition towards a more confirmatory research perspective, since a significant part of the papers analyzed conducted empirical field research, most of them applying the survey-based research method. Most co-cited references about entrepreneurship education could be grouped into three main groups: studies about entrepreneurial behavior and intention; entrepreneurship education and its relation with other subjects of interest; and entrepreneurship education review, challenges, results, and best practices. The country with the largest number of publications in the theme is the United States of America. Concerning the journals, it is interesting that most of these publications in the sample are not from the engineering education area, showing a broad interest in this theme beyond the engineering education field.

6. Conclusions

This study contributes to the construction of a relevant body of knowledge on engineering entre-

preneurship education, evidencing entrepreneurship as an economic catalyst, capable of creating jobs and business value with the development of innovations, a phenomenon that has entrepreneurship education as its foundation. There is a growing interest in understanding and measuring the results of/from entrepreneurship education, in the engineering field, but also from other fields of knowledge.

Entrepreneurship education is in its initial stages of development and the results revealed that definitions of entrepreneurship education are still consolidating, an evidence that can be explored in future research initiatives. Entrepreneurship research has expanded, but it is possible to observe little research focused on identifying the determinants concerning the growth of entrepreneurial aspirations. It is a relatively new field for researches, that emerged mainly after the 1990s, and that is based on an evolving body of knowledge, still recognized as ill-defined and, as a consequence, demanding new and in-depth research. One aspect to be explored is the cultural aspect related with entrepreneurship.

The final results evidenced research gaps and motivated the creation of a new research agenda, particularly concerning studies about the identification of opportunities, the design of courses to teach entrepreneurship, the identification of the most relevant approaches to teach entrepreneurship, and to compare entrepreneurship education learning capabilities before and after the conclusion of the programs. This study has limitations that resulted from methodological choices. The first limitation is the focus solely on entrepreneurship education in the engineering field, an option that was made because of the relevance of this specific research area. The second limitation is the decision to solely rely on two databases, Web of Science and Scopus, and considering for the content analysis only the most-cited papers, ranked based on the equation of the adjusted Impact Factor. This option is justified because it is possible to assume that these databases are able to capture the main contributions published in the area; however, some relevant papers could have been missed.

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